Bell Atlantic

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Director – FCC Relations

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April 29, 1997

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Federal Communications Commission
Office of Secretary

Ex Parte

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, N.W. Rm. 222
Washington, D.C. 20554

Re: CC Docket No. 96-262

Dear Mr. Caton:

The attached letter and attachments are being delivered today to Pat DeGraba of the Common Carrier Bureau and pertain to the above referenced proceeding.

Please enter this material into the record as appropriate and do not hesitate to contact me should you have any questions.

Sincerely,

Joe Mulieri

Attachment

cc: P. DeGraba

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List ABCDE

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April 29, 1997

Ex Parte

Mr. Pat DeGraba
Chief Economist - Common Carrier Bureau
Federal Communications Commission
1919 M Street, N.W. Rm. 222
Washington, D.C. 20554

RE: CC Docket 96-262

Attached are three articles that examine the reduction in toll prices and the impact this has on consumer welfare. The first two consider the postdivestiture introduction of subscriber line charges concurrent with access price reductions. As the commission considers an access reform plan that similarly includes moving usage recovery to flat rate recovery, this postdivestiture experience provides some understanding of the expected toll stimulation that would result from restructuring.

- Attachment 1 (by William E. Taylor and Lester D. Taylor, "Postdivestiture Long Distance Competition," American Economic Review, May 1993, pp. 185-190) shows that, when access price reductions were passed through to customers, usage was stimulated.

- Attachment 2, (by Jerry Hausman, Timothy Tardiff and Alexander Belinfante, "The Breaking up of AT&T and Charges in Telecommunications Regulation: What are the Lessons?" American Economic Review, May 1993, pp. 178-184) shows that access prices reductions stimulated demand, while the fixed line charge did not hurt telephone penetration.

- Attachment 3, (by Carlos Martins-Filho and John W. Mayo, "Demand and Pricing of Telecommunications Services: Evidence and Welfare Implications," The RAND Journal of Economics, Autumn 1993, pp. 439-454) shows that welfare is increased when local calling areas are increased (e.g., when an increase in monthly local charge for an extended calling area is substituted for intraLATA toll usage). This is consistent with the analysis done by Donald Kridel, "A Consumer Surplus Approach To Predicting Extended Area Service (EAS) Development and Stimulation Rates," Information Economies and Policy, volume 3, No. 4, 1988 and discussed in Lester D. Taylor's book Telecommunications Demand in Theory and Practice, Kluwer Academic Publishers, 1994, pp. 163-169.

These articles provide evidence that a (cost-based) decrease usage price concurrent with establishing a fixed line charge will expand toll calling without hurting line penetration, thus enhancing consumer welfare.

Should you have any questions regarding this material please do not hesitate to contact me.

Sincerely,

Joe Juhi

Attachment

Postdivestiture Long-Distance Competition in the United States

By WILLIAM E. TAYLOR AND LESTER D. TAYLOR*

The breakup of the Bell System in 1984 initiated a succession of dramatic changes in the structure of the U.S. telecommunications industry. Divestiture of AT&T's operating telephone companies split the industry vertically into separate local and long-distance companies. Regulators actively encouraged entry and competition in the long-distance market, requiring that equal interconnections with the local network be provided to all long-distance competitors. Finally, new methods of regulating AT&T and the local telephone companies were implemented, including deregulation in some jurisdictions and price-cap regulation for interstate long-distance and carrier access services.

Since 1984, there have also been radical changes in the basic data that describe the interstate long-distance market. Capacity in the market has roughly tripled; where once there was one nationwide long-distance network, there are now nearly four backbone long-distance networks and roughly 500 providers. AT&T's share of interstate switched-services long-distance usage has fallen precipitously from 84 percent in 1984 to 63 percent at the end of 1991 (FCC, 1992b). Over the same period, real interstate long-distance prices fell by about 50 percent, and long-distance demand approximately doubled.

Several observers have attributed these changes to the pressures of competition. In its application to provide competitive long-distance service in Canada, Unitel (1991) pointed to the American example:

> By any standard, the American policy has been a success. Rates have fallen, innovation has increased and usage has grown.

Similarly, in a recent proposal to increase competition in local telephone markets, the U.S. Federal Communications Commission (FCC, 1991a ¶11) asserted that:

> ...competition in the provision of interstate long-distance service has led to sharply reduced rates, a larger variety of service options, and more rapid deployment of new technologies....

While it is tempting to ascribe lower prices and increased demand to the pressures of competition, careful analysis shows that this is not the case.

In this paper, we show that the overall reduction in interstate long-distance prices and expansion of interstate demand is *more than* explained by the reduction in the carrier access charges paid by the long-distance carriers to the local telephone companies.[1] Net of these payments, real interstate long-distance prices fell at about half the rate after 1984 than before. Moreover, regulated competition in the interstate toll market has not led to an expansion of demand. Despite the introduction of new services and massive advertising and marketing efforts, toll demand grew no more than would be ex-

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[1] Long-distance companies (e.g., AT&T, MCI) pay carrier access charges per minute of use to local telephone companies (e.g., New York Telephone) for originating and terminating traffic on their networks. These charges constitute a marginal cost to the long-distance companies.

pected based on changes in price, population, and consumer income. Thus, although the FCC's decision to reduce carrier access charges has resulted in enormous welfare gains for consumers, competition—or at least regulated competition—is not responsible for these benefits. The substantial price reductions and outward shifting of the toll demand curve that would be expected to arise from vigorous toll competition have yet to materialize.

I. The Effect of Competition on Prices

Real interstate long-distance prices fell in half from 1984 to 1991 and fell faster since divestiture than their long-run historical average. From 1984 to 1991, real interstate toll rate reductions averaged about 8.2 percent annually, using the Bureau of Labor Statistics (BLS) producer price index for interstate toll rates, deflated by the BLS GNP-PI. From 1972 to 1983, the longest predivestiture period over which interstate rate data are compiled by the Bureau of Labor Statistics, interstate toll rates declined at an annual average (real) rate of 2.7 percent. Since the postdivestiture period coincides with the period during which equal access became available and during which AT&T lost considerable market share, one might attribute these additional price reductions to increased competition among interexchange carriers. But that would be wrong.

Starting in 1984, the FCC began to rebalance local and toll prices in the United States, primarily through two related activities. First, it shifted recovery of local-telephone-company fixed costs that had previously been recovered from long-distance companies (through carrier access charges) to final consumers (through monthly subscriber line charges). Beginning in 1984, subscriber line charge revenues grew from approximately \$1.296 billion to \$6.069 billion during 1990–1991, and all of that revenue represented lower carrier access charges paid by the interexchange carriers (United States Telephone Association, 1990). Second, the FCC instituted a series of accounting changes which effectively reduced interstate costs while increasing intrastate costs. The net effect of these accounting changes (and other regulatory changes, including changes in income tax rates) was to reduce carrier access charges an additional \$4.493 billion (annually) by 1990–1991. By 1990, carrier access charge expenditures were approximately \$9.266 billion less per year because of these changes in federal regulatory policy, and by July 1992, AT&T was receiving annual reductions in access charges (and other exogenous costs) of approximately \$10.86 billion.

At the same time, AT&T's cumulative *price* reductions produced only \$8.22 billion less revenue per year, compared with 1984 (Taylor, 1992 [exhibit 1]). Thus, net of access charge changes, AT&T's tariffed prices actually grew in nominal terms at an annual rate of about 1.5 percent per year between 1984 and 1992. In real terms, they fell at about 2.2 percent per year. Paradoxically, in a period when AT&T was losing market share rapidly, it nonetheless increased nominal prices (net of access charges).

In addition, we observe much larger reductions in real interstate toll rates (net of access charges) during the period *before* divestiture, equal access, and AT&T's loss of market share. If we adjust interstate toll rates to account for the changes in the non-traffic-sensitive cost assignment in the Ozark Plan between 1972 and 1984, we observe that real interstate toll rates, net of changes in separations, fell at an annual rate of 6.28 percent.[2] Net of access charge changes, then, real interstate toll rates fell roughly twice as fast in the decade before divestiture than in the seven years after.

These findings are hardly consistent with the view that competition among interexchange carriers led to drastically lower prices. Beyond the mandatory reflection of access charge reductions in AT&T's rates (which were followed by the other long-distance providers), interexchange carriers initiated no significant price reductions for

[2] The earliest year for which BLS price data for interstate toll service are available is 1972.

toll services.[3] Since reductions in carrier access charges represent reductions in marginal cost for all long-distance companies, these data are more consistent with the presence of a regulated price umbrella than with a competitive market.[4]

The discussion thus far applies to AT&T's prices for tariffed services. During the same time period, large business customers began to substitute lower-priced bulk discount services (such as Megacom or SDN) for ordinary toll service, and high-volume residential customers were switching to optional calling plans (such as Reach Out America). Our estimate of the reduction in AT&T's tariff prices thus underestimates the reduction in the average price paid by AT&T's customers. While this effect is important for large business customers, it has a very small effect on aggregate prices.[5]

The explanation for this noncompetitive price behavior is not difficult to find. Regulated competition in the U.S. interstate toll markets differs in several important ways from unfettered free competition. The seven regional (former) Bell holding companies are barred from the market, and GTE is subject to a decree which regulates its participation. In addition, the FCC instituted a number of measures to protect new competitors in the market, including access-charge discounts for entrants to compensate for unequal access, non-cost-based access transport pricing which favored the smaller entrants to compensate for AT&T's locational advantage, and asymmetric regulation of AT&T which continues to this day.

II. The Effect of Competition on Demand

A second possible benefit from competition in the interstate toll markets was growth in demand due to more intensive marketing and the introduction of new services. Since divestiture, interstate switched access usage has grown at an annual rate of 11.81 percent (FCC, 1992a table 24), and this measure of demand probably understates demand growth, as it ignores demand served by bypass services, including services like SDN and Megacom.[6] During the 20 years before divestiture, annual growth in interstate usage averaged 10.5 percent (AT&T, 1983). While interstate toll demand did grow more rapidly after competitive entry, this growth was not due to additional new services, advertising, consumer awareness, and so on. The change in the growth rate is completely explained by changes in price, income, and population.

We compare the decade before divestiture (1972–1982) with the period after divestiture (1984–1988).[7] In each period, we

[3]This generalization applies to aggregate interstate toll service. There is evidence of competitive pressure reducing toll rates (i) paid by large business customers (e.g., through new services such as Megacom, Prism, and Ultra-WATS) and (ii) in the intrastate toll markets where long-haul rates fell and short-haul rates rose from 1983 to 1987 (Alan Mathios and Robert P. Rogers, 1989 p. 446).

[4]The gap in prices between AT&T and its competitors shrunk from 10–20 percent in mid-1984 to about 5 percent in 1987 when the unequal access discount was essentially eliminated (Michael E. Porter, 1987). Until equal-access facilities were available to interexchange carriers other than AT&T, those carriers received a 55-percent discount compared with the access prices paid by AT&T.

[5]AT&T calculates that during the 1989–1991 period, prices actually paid by customers fell at an annual rate of 0.9 percent due to the migration of customers to lower-priced services like SDN (Richard Schmalensee and Jeffrey H. Rohlfs, 1992 table II). Assuming conservatively that migration occurred at this rate since 1984, our estimate of AT&T's annual nominal price increase is lowered to 0.6 percent, and our estimate of AT&T's real annual price reductions is raised to 3.1 percent.

[6]Conventional switched long-distance service uses the switched access service of the local telephone company on both ends of the call. Services like Megacom and SDN use a private line to reach the customer on one end of the call, reducing the use of switched access service by half.

[7]We treat the postdivestiture period as the competitive period, although the same analysis as that described below yields the same qualitative results if applied to the 1972–1978 and 1979–1990 periods. To judge the effects of competition on demand growth, it is useful to note that MCI and Sprint advertising was less than $5 million in 1980 compared with $45 million for AT&T (measured in 1986 dollars). Between 1983 and 1984, total annual advertising for AT&T, MCI, and Sprint increased from about $100 million to about $150 million (in 1986 dollars) (Porter, 1987 figure 23).

divide actual demand growth into two parts:

1. *predicted growth*: a part due to changes in prices, income, and population;
2. *unexplained growth*: a (residually measured) part due to other changes—changes in taste, changes in the market place (such as competitive entry), and the like.

If competition shifts the demand curve outward due to advertising, the availability of new products or services, or a heightened awareness of the uses for telephone service, we would expect to see that shift as an increase in unexplained growth.

To explain growth in the demand for interstate switched services, we estimated a quarterly model for aggregate interstate switched access demand using data from the third quarter of 1984 through the second quarter of 1992. The results are in keeping with estimates obtained from other interstate toll demand models:

$$\ln Q_t = \underset{(-1.84)}{-8.70} + \underset{(4.99)}{0.565} \ln Q_{t-1} \underset{(-3.61)}{-0.272} \ln P_t$$

$$+ \underset{(1.87)}{0.422} \ln Y_t + \underset{(1.76)}{1.49} \ln \mathrm{POP}_t$$

where

$\ln Q$ = logarithm of total interstate switched access minutes
$\ln P$ = logarithm of the ratio of the CPI for interstate toll calls to the CPI for all goods and services
$\ln Y$ = logarithm of real disposable personal income
$\ln \mathrm{POP}$ = logarithm of population size

and where t statistics are in parentheses. On 26 degrees of freedom, the R^2 of the model is 0.998, and the Durbin h statistic is -0.60. The long-run price elasticity of -0.63 agrees with other estimates, notably the -0.72 estimate used by the FCC in CC Docket 87-313 (Joseph P. Gatto et al., 1988).

Using this simple model, we calculate the rate of growth of unexplained demand. During the 1972–1982 period, demand was predicted to grow at an annual rate of 6.58 percent. Actual demand growth averaged 8.92 percent, leaving a growth rate of unexplained demand of 2.34 percent. During the 1984–1991 period, the model predicted that demand growth would average 10.79 percent, and actual demand growth averaged 11.81 percent. Thus the growth rate of unexplained demand during the 1984–1991 period averaged 1.02 percent. Growth in demand unexplained by changes in price, income, and population averaged 1.33 percentage points *lower* in the 1984–1991 period compared with the 1972–1982 period.[5]

One possible explanation of this reduction in the growth rate of unexplained demand after divestiture is the growth of bypass–provision of interstate toll minutes of use without using the switched access facilities of the local telephone companies. In our calculation, we measure interstate toll demand as interstate switched access demand after divestiture, and the growth of bypass demand (including services like Megacom and SDN) would mask growth in toll demand after divestiture. To adjust our results for the possibility of bypass, we use industry estimates of interstate bypass usage from 1984 through 1991 (FCC, 1991b) and add that usage to our measure of switched access demand (Taylor, 1992 [exhibit 3]). The annual growth rate of this measure of interstate toll demand averaged 12.90 percent during the 1984–1991 period, so that unexplained growth rose about 1 percentage point to 2.12 percent. Including the effects of bypass, unexplained demand still grew about 0.23 percentage points more slowly in the 1984–1991 period than in the 1972–1982 period.

III. Observable Effects of Competition

Competition in the postdivestiture period among interstate long-distance suppliers did not reduce prices or expand demand, but it did have perceptible effects, at least in cer-

[5]The results are not sensitive to the particular time period chosen or to the precise values of the elasticities. If the price elasticity is taken to be -0.72, (Gatto et al., 1988), unexplained demand growth slows even more after divestiture.

tain market segments. While AT&T's overall market share of switched access minutes of use fell from 84.2 percent in the third quarter of 1984 to 62.8 percent in the fourth quarter of 1991, its share of the large business market fell to about 50 percent. Moreover, AT&T consistently set prices for its business services below their applicable cap under price-cap regulation, and evidence amassed by the FCC suggests that AT&T faces a substantially more elastic (firm) demand curve in the business-services market. Supply elasticities of competitive firms have increased during the period. About 58 percent of AT&T's switched business-services revenue comes from firms that also purchase services from a competitor, and MCI and Sprint together could absorb about 15 percent of AT&T's business traffic without expanding their capacity (FCC, 1991c ¶36, 40, 50). Of course, it is not surprising to observe more lively competition in the market for large business customers: having higher usage, large business customers are more likely to change carriers in response to a given price difference.

Using the aggregate FCC data discussed above, we specified individual-firm demand functions, treating the interstate market as comprising two firms, AT&T and "others." Although we obtained a reasonable market demand equation, we were unable to estimate individual-firm elasticities. These results may be due to poor price data and limited independent variation in those data for AT&T and its competitors, but they are also consistent with lackluster price competition in the market. This is not to say that there has not been competition, even fierce competition, in price in certain submarkets —only that such behavior cannot be isolated in the aggregate data. The conclusion, accordingly, is that meaningful estimation of firm demand functions in the interstate toll market must await the development of a comprehensive data set that is disaggregated by both submarkets and firms.

IV. Conclusions

Competitive entry into interstate long-distance service has undoubtedly resulted in vigorous competition in the large business market. In the aggregate interstate toll market, AT&T's market share has fallen and its (firm) demand curve has accordingly become more elastic. Nonetheless, competition since 1984 has not led to lower prices in the aggregate market or to lower prices for residential and small business customers. In addition, despite massive increases in marketing efforts and a flurry of new service offerings, aggregate interstate toll demand has not shifted outward. Changes in prices (and income and population) fully explain the growth in demand in the postdivestiture period. In sum, regulated competition and asymmetric regulation of AT&T have yet to bring the benefits of lower prices and expanded demand to all interstate telephone customers.

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THE BREAKING UP OF AT&T AND CHANGES IN TELECOMMUNICATIONS REGULATION: WHAT ARE THE LESSONS?[†]

The Effects of the Breakup of AT&T on Telephone Penetration in the United States

By JERRY HAUSMAN, TIMOTHY TARDIFF, AND ALEXANDER BELINFANTE*

The breakup of AT&T in 1984 into a long-distance (and manufacturing) component and seven local-service companies, the Bell operating companies (BOC's), created the opportunity for billions of dollars of annual economic efficiency gains for the U.S. economy. These potential annual efficiency gains arise in part from the establishment of a rational price system for telephone services. At the time of the breakup (and to a lesser extent today) basic access to the telephone network received a large cross subsidy from other telephone services; that is, the price of basic access was well below its incremental (or marginal) cost. The largest component of this cross subsidy arises from the prices of long-distance services which are well in excess of their incremental cost. However, since the price elasticity of basic access is near zero while the price elasticity of long-distance services varies from about -0.25 to -1.2 depending on the type of service, a large economic efficiency loss occurs.

Why did regulation evolve in the United States to cause this extremely large distortion in prices? Numerous reasons can and have been put forward (see e.g., Peter Temin, 1987), but our favorite explanation arises from a combination of an outmoded framework of telecommunications regulation and changing technology. Congressional legislation, which established the Federal Communications Commission (FCC) and remains the basic framework for telecommunications regulation, was the Communications Act of 1934. This legislation led to the current joint regulation of telephone companies by both the FCC and state public utility commissions (PUC's). The Communications Act codified the goal of universal service—the notion that all U.S. households should have telephone service. This policy has been quite successful with U.S. telephone penetration at 93.3 percent in 1990 according to the Current Population Survey (CPS). Yet the FCC is basically in charge of setting long-distance prices while state PUC's are in charge of setting basic access prices, both of which are important factors in telephone penetration. During the post-World War II period the technology was changing so that the cost of long-distance service was decreasing markedly while the cost of labor-intensive basic access continued to rise essentially in line with inflation. The so-called separations system of regulation, established to "divide the cost" of the public telephone network between federal and state regulatory jurisdictions, created increasing cross subsidies as the contribution from long distance grew with increases in both the price–cost ratio of long distance and increases in long-distance demand.

Economists were aware of this problem and in the 1970's recommended that long-distance prices be decreased and basic access prices be increased. Indeed, to a first approximation if the basic access price elasticity is zero, the first-best tax solution of a

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lump-sum tax on basic access is available, which eliminates the loss in economic efficiency. Income-distribution problems arise, but these problems can be solved by a targeted subsidy to low-income households. Yet, state PUC's have been reluctant to raise basic access prices because they perceive that the very small basic access price elasticity could lead to some decrease in telephone penetration. In this paper we present a model of basic residential access demand which demonstrates that these fears are unfounded. Prior econometric estimates have specified models of basic access demand as a function of only its own price. Our estimates also find an important effect of long-distance prices on the demand for basic access. Indeed, the effect of long-distance prices is sufficiently large that a revenue-neutral rebalancing of telephone prices, which would reduce the subsidy for basic access and lower long-distance prices, would lead to both large gains in economic efficiency and *increased* telephone penetration in the United States. Thus, the perceived policy trade-off between economic efficiency and telephone penetration is unlikely to exist any longer.

I. Regulated Price Setting by the FCC and State PUC's

A. *FCC Regulation*

In regulating interstate telephone services, the FCC uses two main approaches to set prices to allow the local exchange carriers (LEC's) to cover their separated cost basis. The first approach is to set a lump-sum tax, called the subscriber line charge (SLC), which is currently $3.50 a month per residential access line. Each residential phone user pays this fee as part of the monthly basic exchange access bill. The other approach used by the FCC is to charge long-distance companies for access from the customer premises to the long-distance companies' network. These access charges are currently about $0.07 per minute of interstate long-distance usage. Access charges are quite substantial since they comprise about 40–50 percent of long-distance companies' overall costs and are over five times the LEC's incremental cost of providing long-distance access. In total, the subscriber line charge plus access charges combine to cover about 25 percent of overall LEC costs, which is the FCC share of separated costs.

B. *State PUC Regulation*

State PUC's set prices for basic exchange access and for intrastate long-distance services. Basic exchange access, which is often offered bundled together with free unlimited local calling (flat-rate tariff) or provides access plus a per-call charge for local calls (measured-rate tariff), has a price which varies from about $8 per month in New Jersey and California to about $23 in West Virginia. When the FCC subscriber line charge is included, the monthly basic access price varies from about $12 to $27. (In October 1990, the FCC reported a national average flat rate of $17.79, including taxes and the subscriber line charge.) The incremental cost of basic access depends on geographical location, but its range is about $18–$24 per month for residential customers. Thus, in most states residential basic access service receives a significant cross subsidy.

Intrastate long-distance service comes in two varieties. IntraLATA long distance calls are provided by the BOC's and also by long distance companies such as MCI and AT&T where permitted by state regulation.[1] Regulated prices of intraLATA calls are set well in excess of the cost of providing these calls. The revenues from BOC-provided intraLATA long-distance service are used to cover BOC costs, including the cross subsidy used to help finance residential basic access. Companies such as MCI and AT&T provide intrastate interLATA long-distance services. Most states have adopted access charges for intrastate long-distance services similar in form to the access-charge frame-

[1] LATA's (local access and transport areas) were established in 1984 at divestiture. BOC's are restricted to providing telephone services only within LATA's.

work used by the FCC. The access charges are again well above cost so that they provide an important source of cross subsidy for residential basic access service.

C. *Overall Effect on Telephone Service Prices*

Basic exchange access is typically set well below its incremental cost and receives a significant cross subsidy. The size of the cross subsidy, at least from interstate toll calls, has decreased since the breakup of AT&T because of the use of the subscriber line charge and the decrease in long-distance access prices. At the state level the size of the cross subsidy may well have increased, since most state PUC's have not increased residential basic access prices along with inflation, while the large labor component of providing copper links from residences to the telephone network has led to increased costs. Since the breakup of AT&T, interstate long-distance prices have decreased by about 40 percent, primarily due to decreases in access charges by the FCC. However, a decrease in FCC access charges down to incremental cost would probably lead to a further reduction in long-distance prices of another 25 percent, at least. Thus, long-distance service continues to cross-subsidize basic-access service as it did before divestiture. We now discuss the likely outcome of a further reduction, or even the elimination, of the cross subsidy by an increase in basic access prices together with a decrease in long-distance access charges, which would cause reduced long-distance prices.

II. A Model of Basic Access Demand

A. *Model Specification*

The decision to purchase basic access service depends on its price as well as the demand for usage of the telephone by the residential consumer. This usage falls into three categories: local usage, intraLATA long-distance calls, and interLATA long-distance calls. Thus, we have a combined discrete-choice equation and continuous demand system for three services which arise from a common decision framework.[2] Here we are interested in the question of whether the household decides to purchase basic exchange service which arises from a partially indirect utility function:

$$u = u(y, \mathbf{p}, \mathbf{q}, z, \varepsilon) \tag{1}$$

where y is household income, $\mathbf{p}$ is a vector of prices for basic exchange access which includes the one-time installation price and the monthly basic exchange price, $\mathbf{q}$ is a vector of prices of usage for local service (whose price is often zero), intraLATA service, and interLATA service, z is a function of household characteristics, and ε is a random parameter which is independently distributed across households.[3] Conditional on purchasing basic exchange access, the three demand equations can be derived via Roy's identity:

$$x_i = \frac{\dfrac{\partial u(y - p_1 - p_2, \mathbf{q}, z, \varepsilon)}{\partial q_i}}{\dfrac{\partial u(y - p_1 - p_2, \mathbf{q}, z, \varepsilon)}{\partial y}} \tag{2}$$

Thus, efficient estimation would involve joint estimation of telephone penetration and the demand equation for telephone services. Since we do not have data on telephone service demand, we instead estimate the basic-exchange-access discrete-choice equation where a household purchases tele-

[2] Models with combined discrete and continuous demand functions arising from a common-decision framework have been estimated in other contexts by Hausman (1979) and by Jeffrey Dubin and Daniel McFadden (1984). Hausman (1985) estimates a further model with this structure and considers the general econometric framework for such models.

[3] A Hicksian composite commodity provides the numeraire price. The observant reader will realize that actually two interLATA prices exist for each household depending on whether a call is interstate or intrastate. We combine these two prices into a price index for interLATA long-distance calls.

phone service if

$$(3)\quad \tilde{u}_1 = \tilde{u}(y - p_1 - p_2, q, z, \varepsilon) \geq \tilde{u}(y, z, \varepsilon) = \tilde{u}_2$$

where u_1 is the partially indirect utility function where basic access price has been subtracted from household income and u_2 is the partially indirect utility function where all consumption is of the composite (non-telephone) commodity. An important finding of equations (1)–(3) is that the discrete choice equation should depend on the basic access price(s) and also on the usage prices. This specification is in marked contrast to almost all other specifications of basic access demand.[4]

B. *Data and Estimation*

To estimate the effect of telephone prices on basic residential access, we acquired data that were collected for and by the FCC for CC Docket No. 87-339. For the years 1984–1988, the data combine telephone penetration and demographic variables from the Current Population Survey with prices collected through the U.S. Telephone Association at the request of the FCC. The data are organized into about 200 geographic areas for the first two years and about 500 geographic areas for the last three years. For each area, information on telephone penetration, demographic variables, and telephone prices is available. The long-distance price variables include a measure of interstate toll prices and a combined measure for intrastate toll prices combining intrastate intraLATA and interLATA prices to form an overall toll-price index using the following procedure. First, for each state, we obtained the 1984 numbers of intrastate toll calls (A) and interstate toll calls (B) for use in a fixed-weight toll index. The index was constructed as follows:

$$\text{toll index} = \frac{B \times (\text{interstate index}) + A \times (\text{intrastate index})}{B + A}.$$

The interstate index was included in the FCC data and the intrastate toll index was the national-level CPI for intrastate toll calls. Flat-rate access prices charged by Bell Telephone companies, which supplemented the lowest-priced access rates from the FCC data, were obtained from the National Association of Regulatory Utility Commissioners' annual publication of "Bell Telephone Companies' Exchange Service Telephone Rates."

The basic specification used is a binary logit model estimated in Berkson-Theil form where the left-hand-side variable is the proportion of households with telephone service and the right-hand-side variables are telephone prices and demographic variables of households.[5] Because of the panel-data structure of our sample, which varies across both time and states, we use a more general stochastic specification than the Berkson-Theil specification. One component of the stochastic disturbance is the usual deviation between the observed proportion and the model prediction which arises because of sampling error and is proportional to within-cell sample size; an additional component of the disturbance arises from a state-specific component of variance which is invariant across time, and the final component varies across both states and time and allows for general specification error. The model was estimated using a feasible generalized least-squares procedure.

The results of the logit model estimation are available from the authors upon re-

[4] Probably the best known of these prior models is Lewis Perl's (1984) model. The only prior exception is Belinfante (1990), in which basic exchange access demand is allowed to depend on interstate long-distance prices.

[5] Because of the high proportion of observations that are in the tail of the distribution, estimation was also done using a probit specification and an arcsine specification. Very similar results were found for all three specifications. The specification tests of Hausman and William Taylor (1981) comparing between and within estimates produced no statistically significant differences.

quest. At 1990 average U.S. prices and penetration levels, the relevant elasticities are as follows (standard errors are in parentheses): installation charge. −0.0206 (0.0032); basic access price for measured rate service. −0.0052 (0.0025); difference between flat and measured rate. −0.0027 (0.0018); intraLATA toll price. −0.0086 (0.0017); intrastate interLATA toll price, −0.0019 (0.0004); interstate interLATA toll price. −0.0055 (0.0011).

The estimated elasticity with respect to the basic access price, −0.005, is quite small, with a 10-percent price increase leading to a 0.5-percent decrease in penetration (approximately 0.005, given a penetration rate of about 0.93). The finding of a very small but significantly nonzero own-price elasticity for residential basic access demand is consistent with prior studies, with the best known paper being Perl (1984). The very small price-elasticity effect has led some regulators to resist raising basic access prices because of the negative effect on telephone penetration. The other important own-price determinant of demand is the installation charge. Note that the elasticity is about four times as large as the elasticity for the monthly price of basic access. Such a large elasticity implies a very large implicit discount rate of over 100 percent per year, which is consistent with previous findings of purchase decisions for consumer durables for low-income households in Hausman (1979) and the findings of Dubin and McFadden (1984).[6]

However, concentration on only the own price effect could lead to incorrect conclusions on the effects of rebalancing telephone service prices. Note that the cross-price elasticity of the demand for basic access service is −0.0086 with respect to the price of intraLATA toll service and it is −0.0055 with respect to the interstate toll price, which demonstrates the complementary nature of basic access demand and local and long-distance telephone usage. The higher estimated cross-price elasticity of intraLATA toll service is consistent with the general finding that own-price intraLATA toll elasticities are smaller in magnitude than interLATA toll elasticities and with the relative expenditures across bill categories. Thus, an increase in basic access prices combined with a decrease in long-distance toll prices (via a decrease in long-distance access prices) could well lead to an *increase* in telephone penetration, rather than a decrease as has been assumed by many regulators.

III. Postdivestiture Price Changes and Telephone Penetration

During the period 1984–1990, FCC and state pricing policies were accompanied by a gain in U.S. telephone penetration from 91.4 percent to 93.3 percent. Ten million additional households subscribed to telephone service, and households without telephone service decreased by 1.1 million. These results are inconsistent with the view that raising basic access price will necessarily lead to decreased penetration when long-distance prices are decreasing.[7]

The SLC accounts for about one-third of the average price of measured-rate basic access in the United States. Thus, use of the own-price elasticity only would lead to a prediction of a decrease in penetration of −0.18 percent. However, the decrease in interstate long-distance prices during the same time period, where 1984 real prices were approximately double 1990 prices, had

[6]A goal of many regulators to increase telephone penetration could well be advanced by allowing new customers to pay the installation charge over an extended period, say 12 months (with interest), instead of requiring an up-front payment.

[7]The results refute definitively the claims by some consumer advocates who predicted that when basic exchange rates increased because of the SLC that large numbers of households would drop off the telephone network. For instance, the Consumer Federation of America and the U.S. Public Interest Research Group predicted in 1985 that 6 million subscribers would cease telephone service between 1984 and 1986. The actual change in subscribers was an increase of about 4.1 million subscribers during this period.

a positive effect on penetration of approximately three times the magnitude of the increase in basic exchange access prices. Overall, the net effect of the increase in basic exchange access prices due to the SLC and decreases in interstate long-distance prices was to increase telephone penetration in the United States by 0.45 percent according to the model estimates.

In addition to the price changes attributable to FCC interstate access-charge policy, prices for basic access and intrastate toll also fell in real terms. In particular, monthly basic-services prices fell by about $0.85,[8] the installation charge fell by about $2.80, and real intrastate toll prices fell by about 30 percent. When these changes are included with the changes from FCC access-charge policy, the model estimates a gain in penetration of 1.3 percentage points, compared to the actual gain of 1.9 percentage points.[9]

The results are consistent with the fact that even low-income (lifeline) customers pay a substantial portion of their monthly bill for toll services. For example, using a sample of actual May 1991 bills from Pacific Bell for California, we calculate that toll calls account for 64.9 percent of the total bill. Thus, any analysis of the effect of price changes on network penetration needs to account for both the price of toll calls and the basic exchange access price.

IV. Conclusion

Economists have long realized that significant gains in economic efficiency would occur if telephone prices were more cost-based and if the cross subsidy for basic residential access were reduced or eliminated. However, the fear of regulators that such a change would lead to decreased telephone penetration has acted as an absolute constraint to proposed changes in many instances. Our model estimates demonstrate that increased economic efficiency need not lead to decreased penetration.

Indeed, the evidence from the period after the breakup of AT&T during the 1980's tends to show that increased penetration resulted in part from the combined effect of higher monthly basic access charges and lower long-distance prices. Further efficiency gains are likely to arise if the procedure continues to eliminate the cross subsidy received by basic exchange access and if long-distance prices are lowered.[10] These changes can come about in either (or both) of two ways. State PUC's can allow LEC's to change their pricing structures. While many state PUC's have set this change as a goal, very few have actually made much progress, in part because of the opposition of consumer advocacy groups. In addition, the FCC could raise the residential subscriber line charge and lower interstate long-distance access charges, although this change may require Congressional approval. Thus, either set of changes may be difficult to implement. However, the current combination of federal and state policy toward regulation of telephone service in the United States has an efficiency loss in the billions of dollars and retards the advancement of the "Information Age" which many individuals believe will increase productivity and lead

[8]Therefore, the net impact of the SLC and the reduction in basic access rates is a real price increase of about $2.20.

[9]Changes in demographic characteristics, particularly income, probably account for the additional increase in telephone penetration. For example, Perl's (1984) model produces an income elasticity of about 0.10. Thus, the change in real family income of about 8 percent between 1984 and 1990 according to CPS data (where both median family income and income of the lowest quintile increased by about 8 percent) would imply about a 0.8-percentage-point gain in penetration. Added to the 1.3-percentage-point gain implied by price changes, the total effect is about 2.1 percentage points, which is close to the actual gain of 1.9 percentage points.

[10]Of course, these changes need to be accompanied by a targeted subsidy program for low-income households. However, almost all states now have well-developed programs for such households.

to many new services for telephone consumers.

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Demand and pricing of telecommunications services: evidence and welfare implications

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and

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Although telephone pricing has received increasing attention in recent years, the geographic patterns of telephone pricing and the corresponding economic consequences of those patterns have remained perplexing to consumers and policymakers and largely unaddressed by economists. In this article we first specify a model of the demand for short (intraLATA) long distance calling. We then draw upon data made available by the recent adoption of extended area service (EAS) in four metropolitan areas to empirically measure the structure of interexchange telephone demand. Given these estimates, and a conceptual framework for analyzing the economic welfare effects, we are able to quantify the consumer-surplus effects of alternative pricing policies. The empirical results indicate that consumer surplus is noticeably enhanced by adopting EAS. But the net economic welfare effects are shown to be sensitive to, among other things, the level of price-cost margins prevailing prior to the implementation of EAS.

1. Introduction

■ Telephone pricing has both intrigued and befuddled economists and policymakers for over a century. Indeed, substantive issues involving both positive and normative questions about telecommunications pricing have proved to be remarkably enduring. Normative economic analysis of telecommunications pricing has led to the development of principles of optimal (quasi-optimal) linear and nonlinear pricing of telephone services. Positive economic analysis of telephone pricing has recognized the role of both federal and state regulatory bodies in establishing telephone pricing levels and patterns. Because regulators are often subject to intense political (interest-group) pressures, regulatory outcomes often more closely reflect the strength of opposing interest groups than the optimal results derived from normative analysis.

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Against this backdrop, a number of recent articles have extended our knowledge of a variety of aspects of telephone service pricing.[1] Yet despite this progress, the geographic patterns of telephone pricing and their corresponding economic consequences remain perplexing. Specifically, for a typical residential customer of telephone services in the United States, calling within the local calling area (LCA) entails a marginal price of zero, with the exception of the opportunity cost of additional time spent on the phone.[2] For calls outside the LCA, however, prices typically reflect call duration, distance of the call, and time of day. Moreover, it is widely acknowledged that the price of these toll services is generally set well in excess of their economically efficient levels.[3] Thus, calls within LCAs create economic distortions because their price (zero) is less than the positive marginal cost of making them.[4] Simultaneously, the price of inter-LCA calls creates an opposing (but possibly larger) economic distortion due to prices that are set above economically efficient levels.[5] Finally, the differences in these price structures occur despite the fact that a very large portion of "local" (i.e., intra-LCA) calling is technologically indistinguishable from "long distance" (i.e., inter-LCA) calling. (See Kahn and Shew (1987).)

The sizes and boundaries of LCAs are quite diverse. For instance, in the United States, the size of LCAs varies from just a few square miles to massive, the latter exemplified by the large LCAs surrounding such cities as Denver, Atlanta, and Birmingham. Indeed, the roughly 2,400 square miles of the Denver local calling area is considerably larger than the entire state of Delaware. Moreover, the particular boundaries of LCAs are often confusing to customers. For example, it is difficult to understand why calls made between Alexandria, Virginia and Great Falls, Virginia (about 25 miles apart) are local calls, while calls between Great Falls and Leesburg, Virginia (about 10 miles apart) are priced as toll calls.[6]

In recent years, LCAs have been expanded in a number of states.[7] These expansions are generally referred to as extended area service (EAS). In this article, we specify a model of the demand for short (intraLATA) long distance calling. We then draw upon data made available by the recent adoption of EAS in four metropolitan areas to empirically measure the structure of interexchange telephone demand. Given these estimates and a conceptual framework for analyzing the economic welfare effects, we are able to quantify the effects of alternative pricing policies.

The article proceeds as follows. Section 2 provides a background discussion of the structure and implementation of extended area service in the four major metropolitan areas

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[1] See, inter alia, Mitchell (1978), Griffin (1982), Park, Wetzel, and Mitchell (1983), Kahn (1984), Kahn and Shew (1987), Griffin and Mayor (1987), Train, McFadden, and Ben-Akiva (1987), and Kaserman, Mayo, and Flynn (1990). For a recent review of the telecommunications pricing literature, see Mitchell and Vogelsang (1991).

[2] Nearly 75% of residential subscribers and almost 50% of business subscribers pay a flat monthly charge and no additional price to call subscribers within the LCA. See NARUC (1989).

[3] Kahn (1984) clearly describes the existence and sources of such inefficiencies. In recent years the magnitude of these inefficiencies has fallen as regulators have reduced (though not eliminated) the degree of long distance-to-local cross-subsidization. For a discussion of the evolution of this pricing phenomenon (as well as an empirical model of its determinants, see Kaserman, Mayo, and Flynn (1990).

[4] We abstract from the network externality here. While the theoretical existence of this externality is incontrovertible, in all likelihood its size is quite small. See Perl (1983).

[5] See Griffin (1982) for an empirical study of these distortions.

[6] Historically the boundaries of LCAs have been justified according to a "community of interest" standard. While there is no single such standard that prevails across all jurisdictions, the most frequently cited indicators of "community of interest" are the absolute and relative intensity of calling volumes between the relevant exchanges. Given the vagueness in these criteria, an interesting question of political economy arises regarding whether such boundaries are determined by interest group pressures suggested by the economic theory of regulation. For a more detailed discussion of this issue, see Martins-Filho (1992).

[7] Proposals to expand LCAs may be initiated by citizens, local exchange companies, or state public utility commissions. They must ultimately be approved by state public utility commissions if the LCA is within a state and by the Federal Communications Commission if it crosses state lines.

in Tennessee. We specify a demand model for telecommunications services to and from these metropolitan areas in Section 3. In Section 4 we present the results of the demand models, which provide the foundation for the welfare estimation. The welfare framework and consumer-surplus impacts associated with EAS are then presented in Section 5. Section 6 contains a discussion of caveats and extensions, and Section 7 concludes.

2. Background

■ In 1990, the Tennessee Public Service Commission ordered South Central Bell to implement an extended area service calling plan for the four major metropolitan areas in Tennessee (Memphis, Nashville, Knoxville, and Chattanooga). The change in the pricing structure associated with the EAS plan, together with data on calling patterns before and after the implementation of EAS, provides a unique opportunity to determine the responsiveness of telecommunications demand to price changes. Moreover, as we see in Section 5, these estimations also permit an evaluation of the consumer-surplus consequences of alternative pricing policies. In the present section, we describe the EAS plan and the demand model employed.

As seen in Table 1, the exchanges affected by the plan were divided into two groups, namely, $CORE$ and NEW. The $CORE$ group corresponds to exchanges that were part of the same local calling area before EAS. The NEW group corresponds to exchanges that were added to $CORE$ to form the larger calling area that emerges with EAS. The number of telephone calls between each $CORE$ (NEW) and NEW ($CORE$) exchange were recorded for each metropolitan area during the three months before and after EAS implementation. We therefore have the following representative observation: $CALLS_{xzt}$, where (x, z) is an ordered pair (therefore, $(x, z) \neq (z, x)$) representing calls from x to z ($x \in CORE$ ($x \in NEW$) and $z \in NEW$ ($z \in CORE$)) in time period t, where $t = 1$ and 2 for the three months before and after EAS introduction, respectively.[8] For convenience, let each pair (x, z) be indexed by i, thus calls from x to z in time t will be denoted by $CALLS_{it}$.

The EAS plan was implemented at different dates for the four metropolitan areas. Because the collection of the post-EAS data was done during the three months immediately following EAS introduction, the collection period for each metropolitan area is different. For Chattanooga and Memphis, the post-EAS data are for July, August, and September 1990; for Knoxville, the data cover the period from mid-July to mid-October; and for Nashville, the data cover August, September, and October. The pre-EAS data correspond to the months of August, September, and October 1989 for all the metropolitan areas. Conceptually, these data will reflect seasonal characteristics of demand for long distance service. In particular, some months of data collection correspond to the summer period, when the number of calls increases substantially. Accordingly, the $CALLS_{it}$ were normalized for seasonal variations.[9]

Calling data were aggregated by time of day (i.e., day, evening, and night calls), type of customer (i.e., residential and business subscribers), type of service (MTS, operator handled, person-to-person, private lines, etc.) and day of the week (i.e., weekdays and weekends). While this level of aggregation creates difficulties in studies that primarily seek to estimate the demand parameters for specific consumer groups or specific types of services, it does not affect our estimation because we are concerned with the aggregate effect of EAS.

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[8] Since the main interest of the study is to determine the economic impact of EAS, the data collection did not involve exchanges that were not affected by EAS. Thus, calls between, for example, a NEW exchange in the Memphis metropolitan area and a NEW exchange in the Nashville metropolitan area were not considered, since these calls were toll calls before and after EAS implementation.

[9] Monthly seasonal adjustment factors for intrastate toll calls in Tennessee were obtained from South Central Bell Telephone.

TABLE 1 Final Cross Sections By Metropolitan Area

Metropolitan Area	*CORE*	*NEH*
Memphis	Memphis/Arlington	Covington
		Moscow
		Somerville
	Collierville	Moscow
		Somerville
Nashville	Nashville/Old Hickory	Ashland City
		Gallatin
		Lebanon
		Murfreesboro
		Pleasant View
		Smyrna
		Springfield
		Watertown
		White House
	Goodlettsville	Gallatin
		Murfreesboro
		Springfield
		White House
Knoxville	Knoxville	Clinton
		Dandridge
		Gatlinburg
		Harriman
		Jefferson City
		Kingston
		Lake City
		Lenoir City
		Loudon
		Maryville
		Oak Ridge
		Oliver Springs
		Rockwood
		Sevierville
		White Pine
	Mascot/Solway	Dandridge
		Jefferson City
Chattanooga	Chattanooga South/Daisy/Georgetown	Cleveland
		Dayton

Another level of aggregation, however, deserves comment. The implementation of EAS creates the possibility of cost savings on metering equipment by the local telephone carrier. Specifically, many of the metering devices installed in the affected exchanges were turned off after EAS adoption. As a result, the data for these particular exchanges were either lost through the elimination of the exchange from the sample or deliberately aggregated to other trunking lines that continued to be assisted by metering equipment. For example, in the Knoxville metropolitan area, the calls from the small exchange of Greenback to Knoxville were combined with the calls from Lenoir City to Knoxville. This reduced the sample size to a total of 148 observations, because the total number of cross-sectional units, N, dropped to 74 and $t = 1, 2$.

The data reveal a significant increase in the calling level after EAS implementation, which indicates a prompt consumer response to the price change. For example, the gross increase in the mean number of calls from the pre-EAS to the post-EAS period ranged from 337% in Chattanooga to 447% in Memphis. Statewide, for telephone exchanges affected by

EAS, the average increase in the number of calls was 379% between the pre-EAS and post-EAS observations. In contrast, the statewide growth rate of toll calls averaged 12.2% in the five years preceding the implementation of EAS.

3. Estimation issues and the empirical model

■ The raw response of observed calling patterns between exchanges affected by the EAS plan suggests a significant demand response from the introduction of EAS. To isolate the structure of consumer responses to the observed price changes, however, it is necessary to formally model the demand for interexchange calling between the affected exchanges. It is to this effort that we now turn.

The implementation of EAS across several metropolitan areas and data on calling patterns both before and after the introduction of EAS generate a pool of cross-sectional and time-series data. The most general specification of our demand model, then, can be given by

$$CALLS_{it} = \beta_{1it} + \sum_{k=2}^{K} \beta_{kit} x_{kit} + e_{it} \tag{1}$$

where x_{kit} is the kth nonstochastic variable associated with cross-sectional unit i in time period t; β_{1it} and β_{kit} are, respectively, the intercept and the slope parameters to be estimated, which may vary across time and cross-sectional units; and e_{it} is an error term. Restrictions to this general specification are commonly placed on both the parameters and the specification of the error.[10] We specify three different parameter structures. The first, referred to as model 1, permits intercepts to be different for certain values of i but restricts them to be constant over time. Specifically, we account for the potential for systematic differences in the demand response to EAS across the *CORE* exchanges affected by the pricing change. The second specification, model 2, allows for cross-sectional differences on the slopes associated with a specific set of regressors while holding the intercept fixed. Finally, model 3 allows for variations on both the intercepts and the slope coefficients across *CORE* exchanges.

While the most common error-structure problems likely to arise in the context of cross-sectional time-series models are well known and relatively easy to deal with, a unique attribute of point-to-point telecommunications demand creates the prospect for an unusual error structure. Specifically, it is possible that increased (decreased) calling from x to z will alter (either up or down) the level of calling from z to x. While it is impossible *a priori* to determine the sign of this cross-exchange correlation, ρ_{xz}, it is clear that failure to account for such correlation will undermine both parameter estimation and hypothesis testing.[11] Accordingly, we develop an estimation procedure designed specifically for this case that will lead to a feasible Aitken estimator of the parameter vector that is asymptotically equivalent to the Aitken estimator and therefore consistent and asymptotically efficient.[12]

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[10] See Judge et al. (1985) for a survey of models that combine time-series and cross-sectional data.

[11] See Judge et al. (1985).

[12] See Martins-Filho and Mayo (1992). To our knowledge, all studies of point-to-point telecommunications demand, with one exception, have ignored the potential for cross-sectional correlation between transposed exchange pairs. Larson, Lehman, and Weisman (1990) accounted for this correlation by explicitly modelling demand in a simultaneous-equations framework, where calls from x to z are endogenously determined by calls from z to x and vice versa. While there is no theoretical reason to prefer our approach to theirs, data limitations point toward the attractiveness of the method developed herein. Specifically, because most (all) studies of point-to-point telecommunications demand combine a large number of cross-sectional units and a small number of time periods, the estimates of the simultaneous-equations approach may prove unreliable. Specifically, as Anderson and Hsiao (1982) have shown, the appeal to large sample consistency of cross-sectional time-series simultaneous-equation model estimates may be lost if relatively few time-series observations are observed.

TABLE 2 Variable Definitions and Pre-EAS Descriptive Statistics

		Mean (Standard Deviation)					
Variable	Definition	Statewide	Memphis	Knoxville	Nashville	Chattanooga	Source
PFMIN	Price of the first minute of a long distance call between exchanges x and z	[illegible] (.047)	.223 (.055)	.195 (.047)	[illegible]	[illegible]	[1]
PADMIN	Price of an additional minute for a long distance call between exchanges x and z	[illegible] (.030)	.158 (.045)	.166 (.036)	[illegible]	[illegible]	[1]
PCALL	Price paid for a call of average duration	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
N	The number of subscribers in exchange x	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MARKET	The product of the number of customers in exchanges x and z, which is a proxy for market size	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
INCOME	Per capita income in exchange x less the fixed monthly charge	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[2]
DISTANCE	The basis for a set of dummy variables representing mileage bands of various distances	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Sources: [1] South Central Bell Telephone Company. [2] Bureau of the Census.

As suggested by the theory of telephone demand developed in Rohlfs (1974), Mitchell (1978), Taylor (1980), and the previous empirical literature[13] on demand estimation, several variables may serve as explanatory variables. Table 2 provides a description of the nonstochastic variables to be used in the estimation of the demand model, and it also provides statewide and metropolitan-area descriptive statistics on these variables.

Because the first-minute charge differs from the charge for additional minutes of calling, the price of a telephone call may be written as

$$PCALL_{xz} = PFMIN_{xz} + \lambda PADMIN_{xz}, \tag{2}$$

where $PFMIN_{xz}$ is the rate for the first minute, $PADMIN_{xz}$ is the rate for additional minutes, and λ is a positive integer. Given that the pre-EAS average call duration was between three and four minutes, we let $\lambda = 3$ for estimation purposes. Consistent with standard demand theory, we expect a negative coefficient associated with this variable.

Per capita income is also likely to affect the observed demand for point-to-point calling. To account for the approximate one-year gap between the pre-EAS and post-EAS observations on per capita income, the latter observations were deflated by the consumer price index. Additionally, while income effects associated with the fixed monthly charge are likely to be small, we subtract such charges from income levels to capture more accurately the influence of income on usage (as opposed to access) levels. Thus our regressor, $INCOME_{xt}$, is the net real per capita income in the originating exchange pair.

The number of calls from x to z is also likely to be positively related to the number of subscribers in each exchange. If there are N_x and N_z subscribers in exchanges x

[13] See, *inter alia*, Deschamps (1974), Infosino (1980), de Fontenay and Lee (1983), and Pacey (1983). For a survey of the literature, see Taylor (1980).

and z, respectively, the total number of possible connections between x and z is given by $MARKET_t = N_x \cdot N_z$, which is used as a regressor representing market size. Because distance (d) is highly correlated with price in the case of telephone pricing, we chose to specify three different distance bands (in miles) and associate dummy variables $DISTDUM_{gt}$, $g = 1, 2, 3$, to each of them. Thus,

$$DISTDUM_{1t} = \begin{cases} 1 & \text{if } d \in (20, 30] \\ 0 & \text{otherwise} \end{cases} \qquad DISTDUM_{2t} = \begin{cases} 1 & \text{if } d \in (30, 40] \\ 0 & \text{otherwise} \end{cases}$$

$$DISTDUM_{3t} = \begin{cases} 1 & \text{if } d \in (40, 50] \\ 0 & \text{otherwise} \end{cases}$$

Because consumers separated by larger distances are likely to have fewer reasons to interact than those in greater proximity, we expect negative signs on the coefficients associated with the distance dummies.

Consistent with prior empirical research on telecommunications demand, we specify a log-linear demand structure for the estimating model. Because the post-EAS prices and some distance variables are zero, however, we cannot impose the log transformation to all the independent variables. In such cases the variables enter the model untransformed. Thus, the final estimations take the form

$$\ln(CALLS_{it}) = f(PCALLS_{it}, \ln MARKET_{it}, \ln INCOME_{it},$$
$$DISTDUM_{1t}, DISTDUM_{2t}, DISTDUM_{3t}), \qquad (3)$$

with the restrictions imposed on the model as described above, and where f is linear in its arguments.

4. Demand estimation results

■ The models were estimated both with ordinary least squares (OLS) and the feasible generalized least squares procedure developed in Martins-Filho and Mayo (1992). To generate estimated generalized least squares (EGLS) estimators, we first applied OLS to all models, obtaining residuals that were used to estimate ρ_{xz}, the cross-exchange error correlation. The estimated value of ρ_{xz}—i.e., $\hat{\rho}$—is then used to obtain $\Omega(\hat{\rho})$, which provides a basis for the feasible Aitken estimator of β. Additionally, given the primarily cross-sectional nature of the data, we performed the Breusch and Pagan (1979) test for heteroskedasticity. The results indicate that we cannot reject the hypothesis of homoskedasticity. Table 3 reports the estimated value for the parameters in models 1–3 and their associated t-statistics, regression R^2s and the estimated value for ρ_{xz}. The results are very encouraging. The models consistently have high explanatory power with R^2s over .91, and virtually all the individual parameters have the expected signs.

Consistent with our expectation, the coefficient on the price variable is negative and highly significant in all the estimated models. Given the estimated parameter values and the average pre-EAS values of the other variables, the pre-EAS price elasticity of demand generated by the estimations ranges from −1.05 to −1.55.[14] Such elasticities are generally consistent with, although somewhat higher than, the findings of earlier studies surveyed by Taylor (1980).

The variable reflecting the size of the market ($MARKET_{it}$) is also highly significant and has a positive coefficient. Thus, an important determinant of the demand for exchange-

[14] To gauge the plausibility of these elasticity estimates, which are measured at pre-EAS prices, we also estimated a series of constant elasticity (double-log) demand models using only positive price data drawn from the pre-EAS cross-sectional observations. The implied price elasticities, which ranged from −1.18 to −1.54, are consistent with those that result from use of the full sample.

TABLE 3 **Demand Estimation Results**

	Model 1		Model 2		Model 3	
Variable[a]	OLS	EGLS	OLS	EGLS	OLS	EGLS
$PCALLS_{ij}$	−2.42*	−2.43*	−1.62*	[illegible]	−2.0[illegible]*	2.00
	(−21.45)	(−18.53)	(−4.96)	[illegible]	−4.[illegible]	(−4.21)
ln $MARKET_{ij}$	.773*	.772*	[illegible]	[illegible]	[illegible]	.752*
	(18.75)	(15.[illegible])	(24.[illegible])	[illegible]	[illegible]	(16.28)
ln $INCOME_{ij}$	.308	.345	[illegible]	[illegible]	[illegible]	[illegible]
	(−1.14)	(−1.22)	(−.25)	[illegible]	[illegible]	(−1.21)
$DISTDUM_{A}$	.462*	[illegible]	.432*	.440*	[illegible]	[illegible]
	(−4.52)	(−3.[illegible])	(−4.[illegible])	[illegible]	(−4.4[illegible])	−3.7[illegible]
$DISTDUM_{B}$	−.766*	[illegible]	[illegible]	[illegible]	−.729*	−.730*
	(−6.09)	(−5.6[illegible])	(−6.[illegible])	(−6.[illegible])	[illegible]	−5.4[illegible]
$DISTDUM_{C}$	[illegible]	−.522*	−.528*	−.54[illegible]*	[illegible]	−.502*
	(−2.74)	(−2.[illegible])	(−2.[illegible])	(−2.[illegible])	[illegible]	(−2.28)
Degrees of freedom						
Model	2	2	[illegible]	[illegible]	[illegible]	[illegible]
Error	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	—	[illegible]	—	[illegible]	—	[illegible]
R^2	[illegible]	.924	[illegible]	[illegible]	[illegible]	[illegible]

* Statistically significant at the [illegible] level.

[a] As described in Section 3, a set of variables was included to account for the possibility that the telecommunications demand structure varies across CORE metropolitan areas and/or over time. Because these variables are not of primary importance here, we omit these results from the table. These additional results are available from the authors upon request.

to-exchange calling is the number of potential connections between the exchanges. Consistent with prior empirical studies of toll demand, the parameter estimates on the income variable are insignificantly different from zero.[17] The coefficients on the distance dummy variables are significant in all the model specifications and have the expected sign. Finally, estimates of cross-sectional and intertemporal shifts in the demand structure (not reported) are varied, with some but not all of the coefficients taking on significance levels of note.[18]

In all models ρ is positive, taking values between .38 and .43 for models 1–3. This positive correlation between the errors in exchange pairs indicates that whenever there is a change in, say, $CALLS_{ij}$ due to its error term, there will be a corresponding positive change in $CALLS_{ji}$ via its error term. Numerically this increase will vary from 38% to 43%, depending on the model considered. The complementarity suggested by our estimates confirms equivalent results obtained by Larson, Lehman, and Weisman (1990), although the estimated "reciprocity" is lower in our case.

5. The economic welfare effects of EAS

■ Evaluation of the demand conditions for exchange-to-exchange telephone service identified in Section 4 provides a springboard from which it is possible to evaluate the economic welfare effects of alternative telephone pricing structures. In this section, we first develop a conceptual framework for evaluating the economic welfare effects of EAS. Next, we employ this framework and the empirical demand estimates generated above to calculate the consumer-surplus impacts associated with the introduction of EAS in Tennessee.

[17] See, for example, Infosino (1980). In contrast to our model, which relies upon per capita measures of income, models that rely on total income within the market area tend to generate significant parameters associated with the income variable. See, for example, Pavey (1983).

[18] Given the mixed significance levels of the cross-sectional and time-series slope and intercept coefficients, we tested the hypothesis of no cross-section demand variations across metropolitan CORE exchanges. The test performed, alternatively, for intercept and slope variations was rejected in nearly all model specifications.